# PATENT ABSTRACTS OF JAPAN

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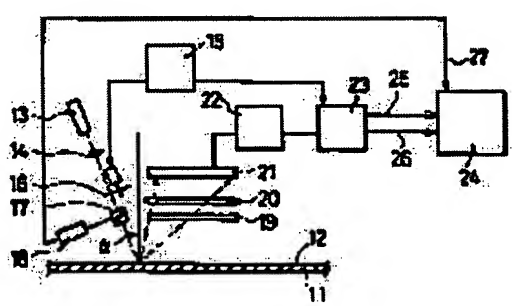
## (54) METHOD AND DEVICE FOR SIMULTANEOUS MEASUREMENT OF EMISSIVITY AND SURFACE TEMPERATURE

(57)Abstract:

PURPOSE: To obtain emissivity of the surface of an object to be measured with a high diffusion reflectivity accurately, easily and rapidly and measure the temperature of the surface of the object to be measured whose emissivity changes and which travels at a high speed.




CONSTITUTION: In a method for measuring emissivity and surface temperature simultaneously, parallel lights with a specified intensity are applied to the surface of an object 11 to be measured while the object is inclined at a specified angle, one-dimensional distribution of the quantity of reflected light and the quantity of heat radiation light is measured at positions which are linearly symmetrical to the direction of irradiation concerning a normal line and at a predetermined distance from the surface 12 of the object 11 to be measured, is measured. Reflectivity is obtained from the distribution of quantity of reflected light, emissivity is calculated from the relationship with the reflection factor, and then a surface temperature is obtained from the emissivity and the measured quantity of heat radiation.

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* NOTICES *



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CLAIMS

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[Claim(s)]
[Claim 1] While irradiating from the direction of radiation which leaned the parallel flux of light which has predetermined intensity the degree of predetermined angle to the front face of a device under test Within the flat surface containing the normal over the aforementioned device-under-test front face, and the aforementioned direction of radiation, to the aforementioned normal, are the aforementioned direction of radiation and a direction symmetrical with a line, and the-like 1-dimensional distribution of the amount of reflected lights from the aforementioned device-under-test front face and the thermal radiation quantity of light is measured in a predetermined distance from the aforementioned device-under-test front face. The simultaneous measurement method of emissivity and a skin temperature characterized by asking for the reflection factor on the aforementioned front face of a device under test from the aforementioned amount distribution of reflected lights, computing the emissivity on the aforementioned front face of a device under test from the relation between this reflection factor and emissivity, and calculating the temperature on the front face of a device under test from this emissivity and the aforementioned thermal radiation quantity of light.
[Claim 2] While irradiating the parallel flux of light which has predetermined intensity to the aforementioned device-under-test front face from the direction of radiation which has a predetermined angle to the normal on the front face of a device under test The aforementioned normal is received within the flat surface containing the aforementioned normal and the aforementioned direction of radiation. in the aforementioned direction of radiation and a direction symmetrical with a line And in a predetermined distance, measure the-like 1-dimensional distribution of the amount of reflected lights from the aforementioned device-under-test front face, and the thermal radiation quantity of light from the aforementioned device-under-test front face, and the 1st optical intensity distribution are obtained. Next, without irradiating the aforementioned parallel flux of light, measure the-like 1-dimensional distribution of the quantity of light from the aforementioned device-under-test front face, and the 2nd optical intensity distribution are obtained. The simultaneous measurement method of of an emissivity and a skin temperature according to claim 1 of asking for the aforementioned amount distribution of reflected lights from the difference of these [ 1st ] and the 2nd optical intensity distribution, and calculating the aforementioned thermal radiation quantity of light from the 2nd optical intensity distribution.
[Claim 3] While irradiating the parallel flux of light of the intensity-modulation light which has predetermined intensity to the aforementioned device-under-test front face from the direction of radiation which has a predetermined angle to the normal on the front face of a device under test The aforementioned normal is received within the flat surface containing the aforementioned normal and the aforementioned direction of radiation. in the aforementioned direction of radiation and a direction symmetrical with a line And in a predetermined distance, the-like 1-dimensional distribution of the amount of reflected lights from the aforementioned device-under-test front face and the thermal radiation quantity of light is measured from the aforementioned device-under-test front face. The simultaneous measurement method of of an emissivity and a skin temperature according to claim 1 of

obtaining the amount of reflected lights and obtaining the aforementioned thermal radiation quantity of light by extracting the aforementioned intensity-modulation light component from this measurement by removing the aforementioned intensity-modulation light component from the-like 1-dimensional distribution of the quantity of light from the aforementioned device-under-test front face.
[Claim 4] Simultaneous measurement equipment of emissivity and a skin temperature characterized by providing the following. The source of luminescence which generates the light of predetermined intensity. Optical system for changing the light from this source of luminescence into the parallel flux of light, and irradiating the aforementioned device-under-test front face at an angle of predetermined from the normal over a device-under-test front face. The 1-dimensional light sensitive cell which receives the reflected light and thermal radiation light from the aforementioned device-under-test front face. Optical system which leads the light of the aforementioned source of luminescence to the aforementioned 1-dimensional light sensitive cell.

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[Translation done.]

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DETAILED DESCRIPTION

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[Detailed Description of the Invention]
[0001]
[Industrial Application] this invention relates to the equipment used for the simultaneous measurement method of emissivity and a skin temperature and this measuring method applicable to the high-speed online manufacturing process of the various steel plates in the steel industry, and a steel pipe etc. at a detail more about the equipment used for the simultaneous measurement method of emissivity and a skin temperature, and this measuring method.
[0002]
[Description of the Prior Art] The radiating-type thermometry which measures the temperature on the front face of a device under test from the thermal radiation quantity of light and the emissivity from a device-under-test front face is a thermometry with early responsibility in non-contact, and various methods are proposed from the former.
[0003] Drawing 8 is the typical cross section of the equipment used by the radiating-type thermometry (refer to the Society of Instrument and Control Engineers 16th volume collected works [ No. 2 (Showa 55) ]) in the conventional example 1, 11 in drawing shows the device under test, and the front face 12 has mirror-plane nature. A device under test 11 is placed into a container 31, and the rotating sector (sector shield) 36 of the water cooling type which rotates by the source 33 of blackbody radiation and the motor 35 is arranged on the irradiation optical axis which has an angle theta to the normal on the front face 12 of a device under test, and the radiometer 37 is arranged to the normal on the aforementioned irradiation optical axis and the reflected light shaft symmetrical with a line. Thus, it is the sum (1st optical intensity) L1 with the thermal radiation light which the irradiation light irradiated from the source 33 of blackbody radiation is reflected on the device-under-test front face 12, and this reflected light and the device-under-test front face 12 emit when measuring the temperature on the front face 12 of a device under test using the constituted equipment and a rotating sector 36 is in the position which does not interrupt the flux of light from the source 33 of blackbody radiation. It is detected by the radiometer 37. Moreover, it is the thermal radiation light (2nd optical intensity) L2 which device-under-test surface 12 the very thing emits when a rotating sector 36 is in the position which interrupts the flux of light from the source 33 of blackbody radiation. It is the typical cross section of the equipment used by the radiating-type [ in / the conventional example 2 / again / in drawing 9 ] thermometry (refer to JP,61-86621,A) detected with a radiometer 37, 11 in drawing shows the device under test, and the front face 12 has mirror-plane nature. The source 13 of luminescence which a mirror 38, a condenser lens 20, and a radiometer 37 are arranged on the normal axis on the front face 12 of a device under test, and irradiates light on the device-under-test front face 12 through a mirror 38 is arranged in the side of a mirror 38. Thus, in the device under test 11 whose reflection factor rho is 1 first when measuring temperature using the constituted equipment, the flux of light is irradiated through a mirror 38 at a different criteria specular reflection board from the source 13 of luminescence, the amount of reflected lights is measured, and it is the luminescence quantity of light L0 of the source 13 of luminescence. It asks. Moreover, it asks for the sum K of rho and epsilon from the reflection factor rho and the body

emissivity epsilon Make it grind and which coming out understands. Next, the sum L1 with the thermal radiation light which the reflected light and the device-under-test front face 12 which transpose the aforementioned criteria specular reflection board to a device under test 11, irradiate the flux of light at a device under test 11, and are reflected on the device-under-test front face 12 emit (1st optical intensity) It measures with a radiometer 37. Moreover, thermal radiation light L2 to which device-under-test surface 12 the very thing emits irradiation light, without irradiating the device-under-test front face 12 (2nd optical intensity) It measures with a radiometer 37. The conventional examples 1 and 2 calculate the emissivity and temperature on the front face 12 of a device under test by the next calculation from such measured value. It is L0, L1, and L2 first. Shell It asks for the reflection factor rho on the front face 12 of a device under test with a-one number.

[0004]

[Equation 1]

$$\rho = (L_1 - L_2) / L_0$$

ただし、$L_0$ ：発光源の発光光量

$L_1$ ：第１の光強度

$L_2$ ：第２の光強度

[0005] Next, it asks for the emissivity epsilon on the front face 12 of a device under test with a-two number from the above-mentioned reflection factor rho.

[0006]

[Equation 2]

$$\varepsilon = 1 - \rho$$

ただし、$\varepsilon$ ：放射率

$\rho$ ：反射率

[0007] However, when the device-under-test front face 12 is a diffusibility reflector, it asks by several 3.

[0008]

[Equation 3]

$$\varepsilon = K - \rho$$

ただし、$\varepsilon$ ：放射率

$\rho$ ：反射率

K ：定数

[0009] Luminance temperature Ta furthermore called for from the 2nd optical intensity And the temperature T on the front face 12 of a device under test is obtained from the above-mentioned emissivity epsilon by the-four number.

[0010]

[Equation 4]

$T = Ta / A \cdot \varepsilon$

ただし、T ：被測定物表面温度

Ta ：輝度温度

ε ：放射率

A ：定数

[0011] Moreover, drawing 10 (a) is the typical cross section of the equipment used by the radiating-type thermometry (refer to iron, steel, the 65th volume, No. 1 (1979), and JP,52-7954,B) in the conventional example 3, 11 in drawing shows the device under test, and the front face 12 has mirror-plane nature. The cylinder 39 with which an inside has specular reflection nature is arranged in right above on the front face 12 of a device under test, and the motor 35 which makes the rotating-sector 36 row which has the opening 40 shown in drawing 10 (b) rotate a rotating sector 36 is arranged on the cylinder 39. Moreover, the radiometer 37 is arranged on the rotating sector 36, and it is arranged so that the medial axis of a cylinder 39, the opening 40 of a rotating sector 36, and the incident-light shaft of a radiometer 37 may be located on the normal axis on the front face 12 of a device under test, respectively. Thus, when measuring the skin temperature of a device under test 11 using the constituted equipment and there is no rotating sector 36 on the normal axis on the front face 12 of a device under test, only the radiant energy E1 which the device-under-test front face 12 emits is detected by the radiometer 37. When the temperature, the emissivity, and radiant energy on the front face 12 of a device under test are set to T, epsilon, and Eb, respectively, the above E1 detected by the radiometer 37 can be expressed like several 5.

[0012]

[Equation 5]

$E1 = \varepsilon \cdot Eb(T)$

ただし、ε ：放射率

Eb ：放射エネルギー

T ：被測定物表面温度

[0013] Moreover, when a rotating sector 36 is on the normal axis on the front face 12 of a device under test, while the thermal radiation light which the device-under-test front face 12 emitted repeats reflection variously between the synchrotron orbital radiation which carries out incidence to the direct radiometer 37 through the opening 40 of a rotating sector 36, and the inferior surface of tongue of a rotating sector 36, the inside of a cylinder 39 and the device-under-test front face 12, the sum with the synchrotron orbital radiation which carries out incidence to a radiometer 37 through the opening 40 of a rotating sector 36 is measured. Thus, radiant energy E2 detected by the radiometer 37 It is expressed with the form where emissivity increased in efficiency, like several 6.

[0014]

[Equation 6]

$E2 = g(\varepsilon) \cdot Eb(T)$

ただし、g（ε）：放射率

Eb ：放射エネルギー

T ：被測定物表面温度

[0015] Since the relation of above-mentioned g (epsilon) and above-mentioned epsilon can be known beforehand, it can ask for the temperature T on emissivity epsilon and the front face 12 of a device under test by solving the above-mentioned several 5 and several 6 as simultaneous equations.
[0016] Moreover, drawing 11 is the typical cross section of the equipment used by the radiating-type thermometry (refer to Japanese-Patent-Application-No. No. 75670 [ 63 to ] official report) of the conventional example 4, and 11 in drawing shows the device under test. An intermittent irradiation equipment (not shown) and aspheric lenses 14, such as the source 13 of luminescence and a chopper, are arranged in the side on the same axle. the upper part of a device under test 11 -- A one-way mirror 17 is arranged by the angle which reflects the parallel flux of light formed of the source 13 of luminescence, and the aspheric lens 14 in the direction of a normal on the front face 12 of a device under test. On the normal on the front face 12 of a device under test, the radiometer 37 is arranged by the distance l (position P) which becomes a fixed rate to the diameter D of the parallel flux of light in the upper part of a one-way mirror 17. Moreover, a mirror 38 is arranged in the parallel flux of light formed of the source 13 of luminescence, and the aspheric lens 14, and the light sensitive cell 18 is arranged in the position where a condenser lens 20 and the parallel flux of light connect a focus with a condenser lens 20 on the optical axis in which a mirror 38 reflects the parallel flux of light, respectively. Moreover, another one-way mirror 41 is arranged between a one-way mirror 17 and a radiometer 37, and the radiometer 42 is arranged in the position in which a one-way mirror 41 reflects the thermal radiation light of the portion shown with the dashed line which the device-under-test front face 12 emits. Thus, when measuring the skin temperature of a device under test 11 using the constituted equipment, and the light from the source 13 of luminescence is formed in the parallel flux of light of an aspheric lens 14 and is irradiated by the device-under-test front face 12 through the one-way mirror 17, it is the quantity of light I0 of the aforementioned parallel flux of light. It measures by the light sensitive cell 18, and is the quantity of light I1 from the device-under-test front face 12. It measures with a radiometer 37. Quantity of light I1 The amount of approximation reflected lights (product of an approximation reflection factor and I0) specified by D/l which the device-under-test front face 12 reflects, and the thermal radiation quantity of light I2 which the device-under-test front face 12 emits It is the sum. Next, it is the thermal radiation quantity of light I2 which the device-under-test front face 12 emits when the parallel flux of light from the source 13 of luminescence is interrupted by intermittent irradiation equipments, such as a chopper. It measures with a radiometer 42. Such measured value to the aforementioned approximation reflection factor is (I1-I2) / I0. It is the thermometer output V0 which it could be found, and emissivity epsilon could be found with (1-approximation reflection factor), and was further called for with the thermal radiation quantity of light. The device-under-test skin temperature T is obtained by following several 7 which shows a relation with the temperature T on the aforementioned emissivity epsilon and the front face 12 of a device under test.
[0017]
[Equation 7]

$$V_0 = A \cdot \varepsilon \cdot T^n$$

ただし、$V_0$　：温度計出力

$\varepsilon$　：放射率

$T$　：被測定物表面温度

$A$、$n$：定数

[0018]
[Problem(s) to be Solved by the Invention] In the radiating-type thermometry of the above-mentioned conventional examples 1 and 2, when the device-under-test front face 12 is not specular reflection nature but diffuse reflection nature, in order that the synchrotron orbital radiation (noise light) from the circumference may carry out diffuse reflection on the device-under-test front face 12 and may carry out

incidence to a radiometer 37, the measurement error of emissivity and temperature is large. Moreover, since a relation with two above is not materialized between emissivity epsilon and a reflection factor rho Since ., however Parameter P which introduce the parameter P like the rho=P (1-epsilon) showing the diffuse reflection property on the front face 12 of a device under test, and have the amendment need in a reflection factor rho change with the quality of the material of a device under test 11, surface roughness, oxidization degrees, etc., For example, there was a problem that high measurement of precision could not be performed, in the high-speed online manufacturing process of the various steel plates in the steel industry, and a steel pipe.

[0019] Moreover, approaching and arranging a cylinder 37 in the device-under-test front face 12, and maintaining cylinder 37 inside at mirror-plane nature, although the accuracy of measurement improves in the radiating-type thermometry of the above-mentioned conventional example 3 since the synchrotron orbital radiation (noise light) from the circumference is not mixed in a radiometer 37 with a cylinder 39 had the problem of being difficult, in the high-speed online manufacturing process of the various steel plates in the steel industry, and a steel pipe.

[0020] moreover, in the radiating-type thermometry of the above-mentioned conventional example 4 Since the latus parallel flux of light is irradiated from a normal to the device-under-test front face 12 and the thermal radiation light and the reflected light from the device-under-test front face 12 are measured By there being little influence of the synchrotron orbital radiation (noise light) from the circumference, and being able to apply also to the device under test 12 of a diffuse reflection nature front face, further, since measurement is called for the degree of capital, it can become easy to emissivity amend emissivity, for example, it can be applied also to the high-speed online manufacturing process of the various steel plates in the steel industry, and a steel pipe. However, there was a problem that the precision of emissivity is inadequate in order to use an approximation reflection factor, and begin an aspheric lens, and equipment was enlarged and automation of a gaging system was inadequate.

[0021] this invention is automatically made and systematized in view of such a technical problem, and it is small and aims at offering the equipment which maintenance nature uses for the simultaneous measurement method of of a good highly precise emissivity and a good skin temperature, and this method.

[0022]

[Means for Solving the Problem] The simultaneous measurement method of emissivity and a skin temperature which starts this invention in order to attain the above-mentioned purpose While irradiating from the direction of radiation which leaned the parallel flux of light which has predetermined intensity the degree of predetermined angle to the front face of a device under test Within the flat surface containing the normal over the aforementioned device-under-test front face, and the aforementioned direction of radiation, to the aforementioned normal, are the aforementioned direction of radiation and a direction symmetrical with a line, and the-like 1-dimensional distribution of the amount of reflected lights from the aforementioned device-under-test front face and the thermal radiation quantity of light is measured in a predetermined distance from the aforementioned device-under-test front face. It asks for the reflection factor on the aforementioned front face of a device under test from the aforementioned amount distribution of reflected lights, the emissivity on the aforementioned front face of a device under test is computed from the relation between this reflection factor and emissivity, and it is characterized by calculating the temperature on the front face of a device under test from this emissivity and the aforementioned thermal radiation quantity of light.

[0023] Moreover, while irradiating the parallel flux of light which has predetermined intensity to the aforementioned device-under-test front face in the simultaneous measurement method of the above-mentioned emissivity and a skin temperature from the direction of radiation which has a predetermined angle to the normal on the front face of a device under test The aforementioned normal is received within the flat surface containing the aforementioned normal and the aforementioned direction of radiation. in the aforementioned direction of radiation and a direction symmetrical with a line And in a predetermined distance, measure the-like 1-dimensional distribution of the amount of reflected lights from the aforementioned device-under-test front face, and the thermal radiation quantity of light from

the aforementioned device-under-test front face, and the 1st optical intensity distribution are obtained. Next, it is characterized by measuring the-like 1-dimensional distribution of the quantity of light from the aforementioned device-under-test front face, obtaining the 2nd optical intensity distribution, without irradiating the aforementioned parallel flux of light, asking for the aforementioned amount distribution of reflected lights from the difference of these [ 1st ] and the 2nd optical intensity distribution, and calculating the aforementioned thermal radiation quantity of light from the 2nd optical intensity distribution.

[0024] Moreover, while irradiating the parallel flux of light of the intensity-modulation light which has predetermined intensity to the aforementioned device-under-test front face in the simultaneous measurement method of the above-mentioned emissivity and a skin temperature from the direction of radiation which has a predetermined angle to the normal on the front face of a device under test The aforementioned normal is received within the flat surface containing the aforementioned normal and the aforementioned direction of radiation. in the aforementioned direction of radiation and a direction symmetrical with a line And in a predetermined distance, the-like 1-dimensional distribution of the amount of reflected lights from the aforementioned device-under-test front face and the thermal radiation quantity of light is measured from the aforementioned device-under-test front face. It is characterized by obtaining the amount of reflected lights and obtaining the aforementioned thermal radiation quantity of light by removing the aforementioned intensity-modulation light component from the-like 1-dimensional distribution of the quantity of light from the aforementioned device-under-test front face by extracting the aforementioned intensity-modulation light component from this measurement.

[0025] Moreover, the simultaneous measurement equipment of emissivity and a skin temperature concerning this invention The source of luminescence which generates the light of predetermined intensity, and the optical system for changing the light from this source of luminescence into the parallel flux of light, and irradiating the aforementioned device-under-test front face at an angle of predetermined from the normal over a device-under-test front face, It is characterized by having the 1-dimensional light sensitive cell which receives the reflected light and thermal radiation light from the aforementioned device-under-test front face, and the optical system which leads the light of the aforementioned source of luminescence to the aforementioned 1-dimensional light sensitive cell.

[0026]

[Function] When light is irradiated by the device-under-test front face, between an incident light, the reflected light, and absorption light, the law of conservation of energy shown by following several 8 is materialized.

[0027]

[Equation 8]

$$I_o = \rho I_o + \alpha I_o + \beta I_o$$

ただし、$I_o$ ：入射光強度

$\rho$ ：反射率

$\alpha$ ：吸収率

$\beta$ ：透過率

[0028] Moreover, if emissivity is set to epsilon from Kirchhoff's law and an absorption coefficient is set to alpha, following several 9 will be materialized.

[0029]

[Equation 9]

$$\varepsilon = \alpha$$

[0030] Drawing 2 is a conceptual diagram for explaining each angle of an incident light and the

reflected light. When light carries out incidence from BO to O point of measurement on a flat surface A, and reflects in the direction of OC and it is based on a normal ON shaft and OX shaft on a flat surface A, (theta, phi), and angle of reflection are expressed with (theta', phi') for the incident angle of light. It is opaque, and when the light of wavelength lambda carries out incidence to the device-under-test front face of a plane with an incident angle (theta, phi) and reflects in it with angle of reflection (theta', phi'), since the conditions of beta= 0 and a flat surface to the reflection factor rho is rho=rho (2pi) from the conditions that a device under test is opaque (hemispheric reflectance) and a reflection factor and emissivity are the functions of wavelength lambda and an incident angle (theta, phi), following several 10 is obtained from several

[0031]

[Equation 10]

$$\varepsilon\ (\lambda : \theta,\ \phi) = 1 - \rho\,(2\pi)\ \ (\lambda : \theta,\ \phi)$$

ただし、$\varepsilon$ ：放射率

$\lambda$ ：波長

$\theta$、$\phi$ ：入射角

$\rho\,(2\pi)$ ：半球反射率

[0032] However, the aforementioned hemispheric reflectance rho in several 9 (2pi) Although it asks from the normal on this front face of a device under test as a reflection factor rho of the reflected light to an incident angle (theta, phi) and conjugate angle of reflection (theta', phi') when a device-under-test front face is specular reflection nature, when a device-under-test front face is diffuse reflection nature, it does not ask as mentioned above. It sets to this invention and is the aforementioned hemispheric reflectance rho (2pi). It replaces with, and application is made possible when a device-under-test front face is diffuse reflection nature by calculating the approximate value rho of hemispheric reflectance.

[0033] Drawing 3 is a conceptual diagram for explaining the principle of the simultaneous measurement method of emissivity and a skin temperature. Intensity I0 predetermined [ the direction AO of the angle / on drawing 3 and as opposed to normal OO' to the point of measurement O on the device-under-test front face 12 / alpha to ] When the parallel flux of light which it has is irradiated, the quantity of light detected by the 1-dimensional light sensitive cell 21 which is in the position of Distance L from a device-under-test front face is set to I1 -In (n is the number of pixels of the 1-dimensional light sensitive cell 21). The quantity of light distribution detected when the quantity of light distribution then detected by the 1-dimensional light sensitive cell 21 comes to be shown in drawing 4 (a) and the parallel flux of light is not irradiated came to be shown in drawing 4 (b). In addition, as for the thermal radiation light intensity from the device-under-test front face 12, and Ii-I0i (however, i=1-n), the parallel flux of light of I0in drawing i is the reflected light intensity reflected on the device-under-test front face 12. The reflection factor distribution on the front face 12 of a device under test is expressed like following several 11 here, when the function R of the degree delta of angle of reflection (delta) is used.

[0034]

[Equation 11]

$$R(\delta_1) = (I_1 - I^0{}_1) / I_0$$

$$R(\delta_2) = (I_2 - I^0{}_2) / I_0$$

$$\vdots \qquad \vdots$$

$$\vdots \qquad \vdots$$

$$R(\delta_n) = (I_n - I^0{}_n) / I_0$$

ただし、$R(\delta_i)$ ：反射角度δの反射率関数

$I_i$ ：第１の光強度

$I^0{}_i$ ：第２の光強度

$i$ ：１，２，・・・，ｍ，・・・，ｎ

[0035] However, an actual reflection factor is the m-th light sensitive cell Dm from which there is amendment need since the distance of point of measurement O and each light sensitive cell differs, and Ii (however, i=1-n) becomes the maximum. When based on angle sigmam and Distance L which the straight line and normal OO' which contract point of measurement O make, it is amendment reflection factor function R'. It can express like following several 12.

[0036]

[Equation 12]

$$R'(\delta_m) = R(\delta_m) \cdot (L / \cos(\delta_m))^2 / L^2$$

$$= R(\delta_m) / \cos^2(\delta_m)$$

$$R'(\delta_{m+1}) = R(\delta_{m+1}) / \cos^2(\delta_{m+1})$$

$$\vdots \qquad \vdots$$

$$\vdots \qquad \vdots$$

$$R'(\delta_n) = R(\delta_n) / \cos^2(\delta_n)$$

ただし、$R'(\delta_i)$ ：反射角度$\delta_i$の補正反射率関数

$R(\delta_i)$ ：反射角度$\delta_i$の反射率関数

$i$ ：ｍ，ｍ＋１，・・・，ｎ

[0037] However, when the device-under-test front face 12 is generally a diffusibility front face, it also sets again, and it is an illuminating angle theta 1. It receives, is related with a normal and is the conjugate angle theta 1. Since the reflection factor which can be set is the largest, it is deltam =theta1. It is deltam, as it becomes, therefore is shown in drawing 3. When the angle with each pixel to make is set to theta, it is amendment reflection factor function R'. It is expressed

[0038]

[Equation 13]

$R'(\theta_i) = R'(\delta_i)$

ただし、$R'(\theta_i)$：$\delta_m$と各画素とのなす反射角度$\theta_i$における補正反射率関数

$i$：$m, m+1, \cdots, n$

[0039] On the other hand, the reflection factor distribution Rs of the direction of theta in case the flux of light is irradiated by the device-under-test front face 12 from a normal can be approximated by following several 14. In addition, alpha and beta are constants decided by granularity on the front face 12 of a device under test etc.

[0040]

[Equation 14]

$Rs(\theta) = \beta \cdot \exp(-\alpha \cdot \theta)$

ただし、$Rs(\theta)$：反射角度$\theta$における補正反射率関数

$\alpha$、$\beta$：定数

[0041] Since several 13 and several 14 express the angular distribution of the same reflection factor as mentioned above, alpha and beta of an unknown are called for by the least squares method, and it is alpha=C 1 now. And beta=C 2 If it carries out, the reflection factor rho on the front face 12 of a device under test (theta) will serve as rho(theta) =C2 and exp (-C1 and theta), and it is hemispheric reflectance rho (2pi) further. Following several 15 asks. Therefore, presumption becomes possible also about the reflection factor distribution of the angle range (larger angle than theta in drawing 3) which cannot be measured by the 1-dimensional light sensitive cell 21.

[0042]

[Equation 15]

$$\rho(2\pi) = \int_0^{2\pi} d\phi \int_0^{\pi/2} \rho(\theta) \cdot \sin(\theta) \cdot \cos(\theta)\, d\theta$$

ただし、$\rho(2\pi)$:反射角度（$\phi$，$\theta$）における半球反射率

[0043] The emissivity epsilon on the front face of a device under test is epsilon=1-rho (2pi) by the above. It will ask and temperature will be further obtained from this emissivity and the aforementioned thermal radiation quantity of light I01.

[0044] In addition, the same operation is brought about, even if the source of luminescence besides [ to the source of luminescence by the chopper etc. ] an intermittent cover means works intermittently as the above-mentioned intermittent irradiation method or it uses intensity-modulation light.

[0045]

[Example] The example of the equipment hereafter used for the simultaneous measurement method of emissivity and a skin temperature and this method concerning this invention is explained based on a drawing.

[0046] Drawing 1 is the block block diagram having shown typically one example of the emissivity concerning this invention, and the equipment used for the simultaneous measurement method of a skin temperature, and 11 in drawing shows the device under test. On the irradiation optical axis which has an angle alpha to the normal on the front face 12 of a device under test, the one-way mirror 17 attached so that a part of chopper 16 to which the source 13 of luminescence, an aspheric lens 14, and reference

frequency VCO 15 were connected, and irradiation light might be reflected is arranged, and the light sensitive cell 18 is arranged on the reflected light shaft of a one-way mirror 17. Moreover, a narrow band filter 19, a condenser lens 20, and 1-dimensional CCD (electric charge joint element)21 are arranged in the reflected light shaft side of the device-under-test surface 12 upper part. 1 more-dimensional CCD21 is connected to the computing element 24 through amplifier 22, the sampling, and the hold circuit 23, and reference frequency VCO 15 is connected to the sampling and the hold circuit 23. In addition, what arranged two or more light sensitive cells in in the shape of-dimensional [ 1 ] is sufficient as 1-dimensional CCD21.

[0047] Thus, when measuring using the constituted equipment, the device-under-test front face 12 is irradiated through the chopper 16 which changes into the parallel flux of light the light first formed in the source 13 of luminescence by the aspheric lens 14, and is driven with reference frequency VCO 15. A narrow band filter 19 is penetrated, it is condensed with a condenser lens 20, and the light reflected or emitted in the device-under-test front face 12 is changed into an electrical signal by 1-dimensional CCD21, and is amplified with amplifier 22. The electrical signal furthermore inputted into the sampling and the hold circuit 23 is changed into the sum signal 25 of a reflected light signal and a thermal radiation lightwave signal by it when the reference frequency from reference frequency VCO 15 irradiates intermittently, when not irradiating intermittently, it is changed into the thermal radiation lightwave signal 26, and it is inputted into a computing element 24. Moreover, the irradiation lightwave signal 27 detected by the light sensitive cell 18 is also inputted into a computing element 24. It asks for reflected light intensity by the computing element 24 from the difference of the sum signal 25 of a reflected light signal and a thermal radiation lightwave signal, and the thermal radiation lightwave signal 26, and asks for a reflection factor from reflected light intensity and the irradiation lightwave signal 27, and the emissivity and temperature on the front face 12 of a device under test are obtained.

[0048] When this equipment is used for below and distance of 1.4 micrometers, the device-under-test front face 12, and 1-dimensional CCD21 is set [ the angle alpha of irradiation light and a normal to make ] to 30mm for 1 degree or less and the main wavelength of a narrow band filter 19, the result which approximated the reflection factor distribution with survey or the reflection factor function (several 13), respectively about the steel plate (1) near specular reflection nature and the steel plate (2) of diffuse reflection nature is shown in drawing 5. Moreover, hemispheric reflectance rho for which asked for the constants alpha and beta in several 14 by the least squares method, and it subsequently asked to the degree of wide angle further by several 15 using the reflection factor data surveyed at an angle of [ of 0-16 degrees ] the reflected light with this measurable equipment (2pi) The steel plate (1) was 0.7, and the steel plate (2) was 0.6.

[0049] Although the reflection factor of a steel plate (1) is high in a narrow angle, it falls in the degree of wide angle, and although the reflection factor of a steel plate (2) is low, with a narrow angle, reflection maintains it also in the degree of wide angle, so that more clearly than drawing 5. Therefore, by the conventional method, the reflection factor of a steel plate (1) was high, and the reflection factor of a steel plate (2) had a possibility that it might be caught low. however, presumption of a reflection factor distribution wide range by this measuring method -- eye a possible hatchet -- a steel plate (1) and (2) -- abbreviation -- the method which the equal reflection factor is obtained and starts this example -- it turns out that the emissivity to the device under test of diffuse reflection nature is called for with a sufficient precision very simply

[0050] Furthermore, in the same conditions as the above, it oxidizes at an elevated temperature using a steel plate (1), and change of the emissivity by generation of an oxide film etc. and the temperature change accompanying this are shown in drawing 6 with the measured value by the thermocouple made to weld on the surface of a steel plate (1). By the method which set the conventional emissivity constant, although temperature measurement precision was **20 degrees C, by the method concerning this example, temperature measurement precision is less than **5 degrees C so that clearly [ in drawing 6 ], and even if emissivity changes by generation of an oxide film, i.e., change of diffuse reflection nature, it turns out that it can measure with a sufficient precision.

[0051] Next, another example of the equipment used for the simultaneous measurement method of

emissivity and temperature and this method concerning this invention is explained based on a drawing. Drawing 11 is the block block diagram having shown typically one example of the equipment used for the simultaneous measurement method of emissivity and temperature concerning this invention, and 11 in drawing shows the device under test. On the irradiation optical axis of the angle alpha to the normal on the device-under-test front face 12, the one-way mirror 17 attached so that a part of light source 13 in which intensity modulation was carried out by the reference frequency generator 15 and the light source power supply 28, aspheric lens 14, and irradiation light might be reflected is arranged, and the light sensitive cell 18 is arranged on the reflected light shaft of a one-way mirror 17. Moreover, on the reflected light shaft of the device-under-test surface 12 upper part, a narrow band filter 19, a condenser lens 20, and 1-dimensional CCD21 are arranged. 1 more-dimensional CCD21 is connected to the computing element 24 through a low pass filter 30 and amplifier 31. Moreover, 1-dimensional CCD21 is connected also to the lock-in amplifier 29, and the lock-in amplifier 29 is connected to the reference frequency generator 15 and the computing element 24. Moreover, a light sensitive cell 18 is connected to the lock-in amplifier 36, and the lock-in amplifier 36 is connected to the reference frequency generator 15 and the computing element 24.

[0052] When measuring using the equipment by which such composition was carried out, the light of the light source 13 by which intensity modulation was carried out first is changed into the parallel flux of light by the aspheric lens 14, and the device-under-test front face 12 is irradiated. A narrow band filter 19 is penetrated, it is condensed with a condenser lens 20, and the light reflected or emitted in the device-under-test front face 12 is changed into the light-receiving electrical signal 33 by 1-dimensional CCD21. The light-receiving electrical signal 33 is changed into the modulation frequency signal 34 and this signalling-frequency component 32, i.e., a reflected light signal, by the lock-in amplifier 29. Moreover, conversion amplification of the light-receiving electrical signal 33 is carried out by the low pass filter 30 and amplifier 31 at the sum signal 37 of a dc component, i.e., thermal radiation, and reflected light component actual value. Moreover, the criteria lightwave signal 35 detected by the light sensitive cell 18 is changed into the modulation frequency signal 34 and this signalling-frequency component 27, i.e., an irradiation lightwave signal, by the lock-in amplifier 36. In a computing element 24, the reflected light signal 32, the sum signal 37 of thermal radiation and reflected light component actual value, and the irradiation lightwave signal 27 are inputted, and it asks for a reflection factor from the reflected light signal 32 and the irradiation lightwave signal 27, and asks for thermal radiation intensity from the relation of the sum signal 37 of the reflected light signal 32, thermal radiation, and reflected light component actual value, and the emissivity and temperature on the front face 12 of a device under test are obtained.

[0053] This equipment was used for below and it measured by making the steel plate (1) which set distance of 1.4 micrometers, the device-under-test front face 12, and 1-dimensional CCD21 to 30mm for 1 degree or less and the main wavelength of a narrow band filter 19, and used the angle alpha of irradiation light and a normal to make for the above-mentioned example, and (2) into a device under test. hemispheric reflectance rho (2pi) which asked the row for the constants alpha and beta in several 14 by the least squares method using the reflection factor data surveyed at the angle of 0-16 degrees as a result of approximating a reflection factor distribution with survey or a reflection factor function (several 13), and was subsequently further presumed to the degree of wide angle by several 15 respectively -- the above-mentioned example and abbreviation -- it was the same It turns out that the emissivity to the device under test of diffuse reflection nature is called for with a sufficient precision very simply by the method concerning this example.

[0054]

[Effect of the Invention] If it is in the simultaneous measurement method of emissivity and a skin temperature concerning this invention as explained in full detail above, since it is carried out based on measurement of an one-dimension-distribution of the amount of reflected lights, or the amount of synchrotron orbital radiation, a reflection factor or an emissivity row is simultaneously asked for a skin temperature simply. Moreover, since a still wide range reflection factor distribution is presumed by calculation from the one-dimension-distribution data of the limited angle range, the device under test of

specular reflection nature can ask accuracy for the emissivity and skin temperature to a large device under test of the diffuse reflection nature which was able to calculate only the inaccurate value more by the conventional method from the first.

[0055] Moreover, if it is in the simultaneous measurement equipment of emissivity and a skin temperature concerning this invention, since automatic calculation systems, such as a computing element, are also incorporated, the simultaneous automatical measurement of the emissivity of a device under test and a skin temperature to which the device under test and emissivity which move at high speed are changed every moment can be attained. Moreover, if it is in the simultaneous measurement equipment of emissivity and a skin temperature concerning this invention, minor-diameter-izing of the aspheric lens which forms the parallel flux of light is possible, and the miniaturization of irradiation light equipment can be attained.

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[Translation done.]

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DRAWINGS

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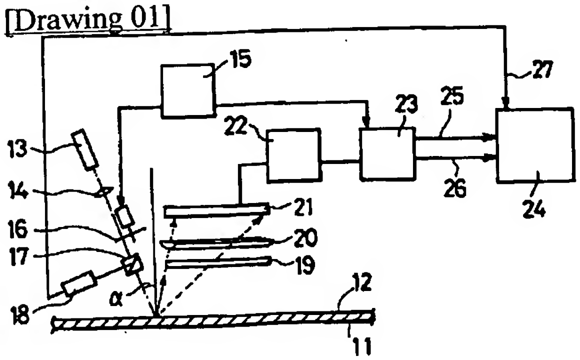
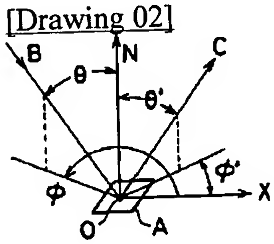
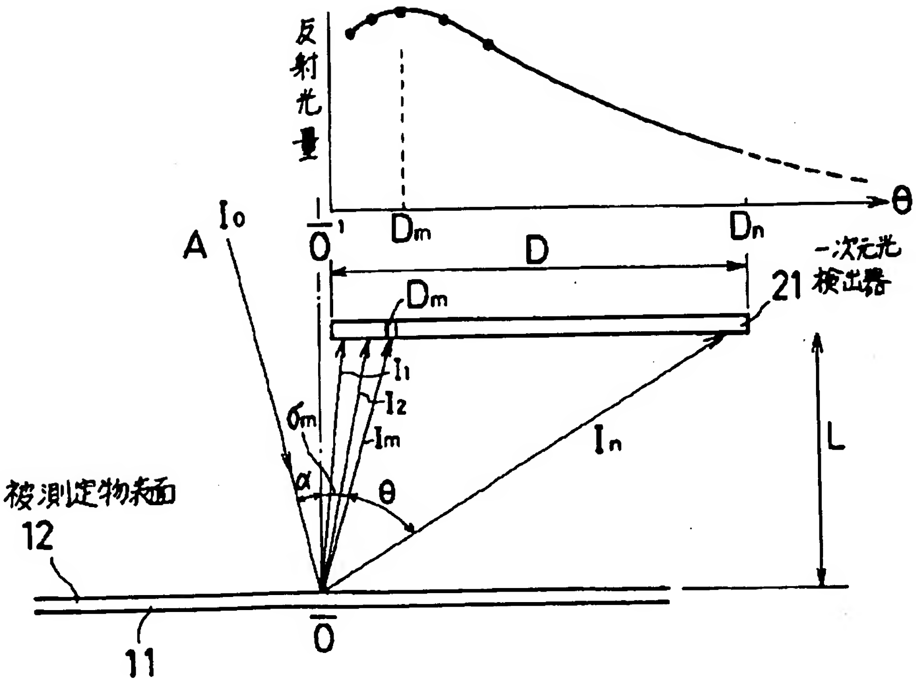
[Drawing 01]



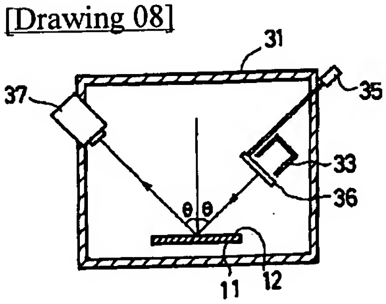

[Drawing 02]



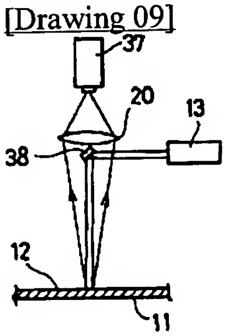

[Drawing 03]




[Drawing 08]

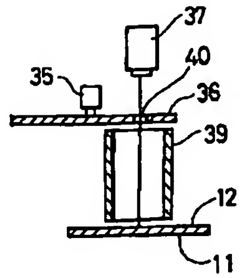



[Drawing 09]

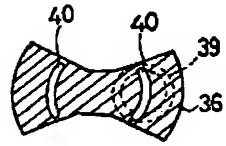



[Drawing 10]

(a)

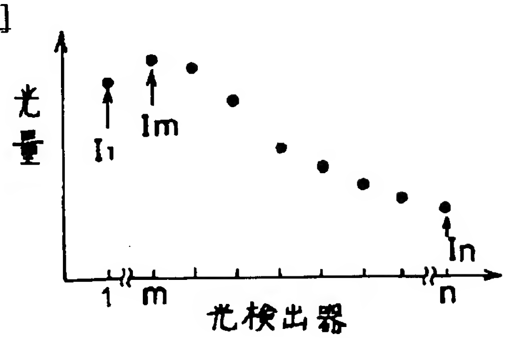



(b)

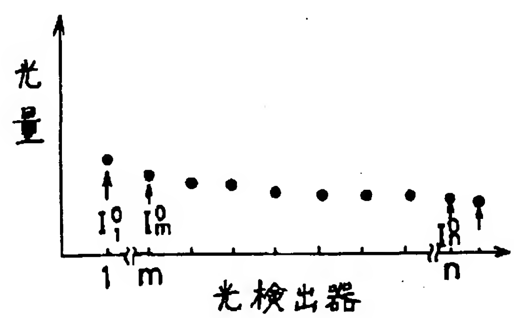



[Drawing 04]

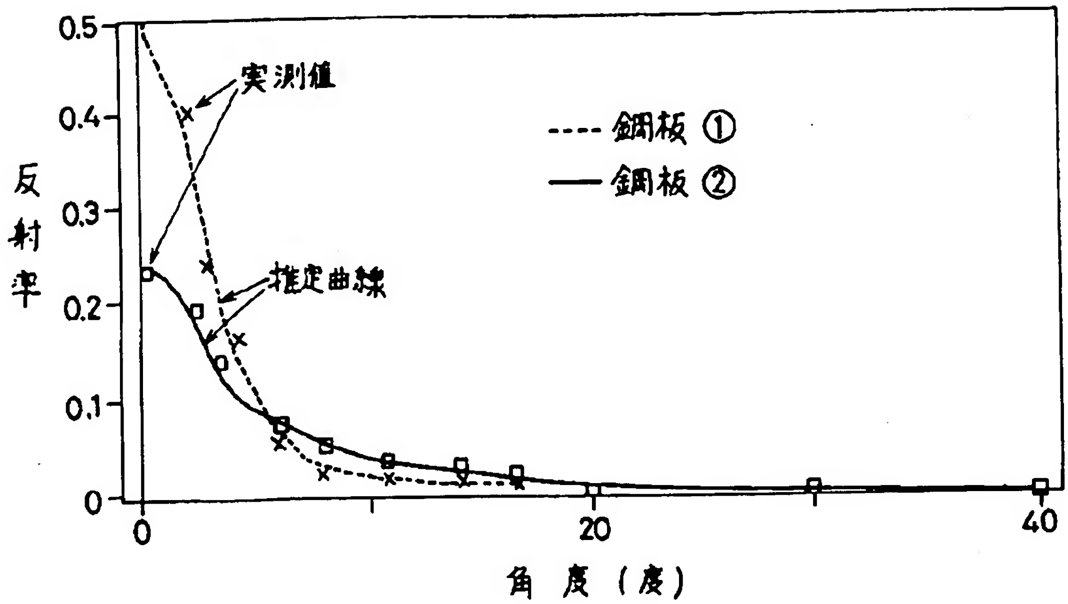
(a)



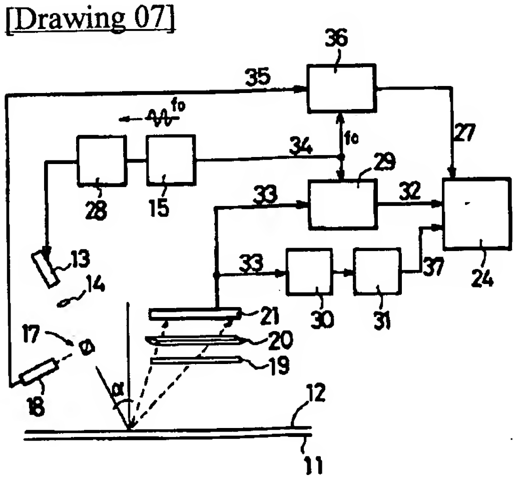

(b)



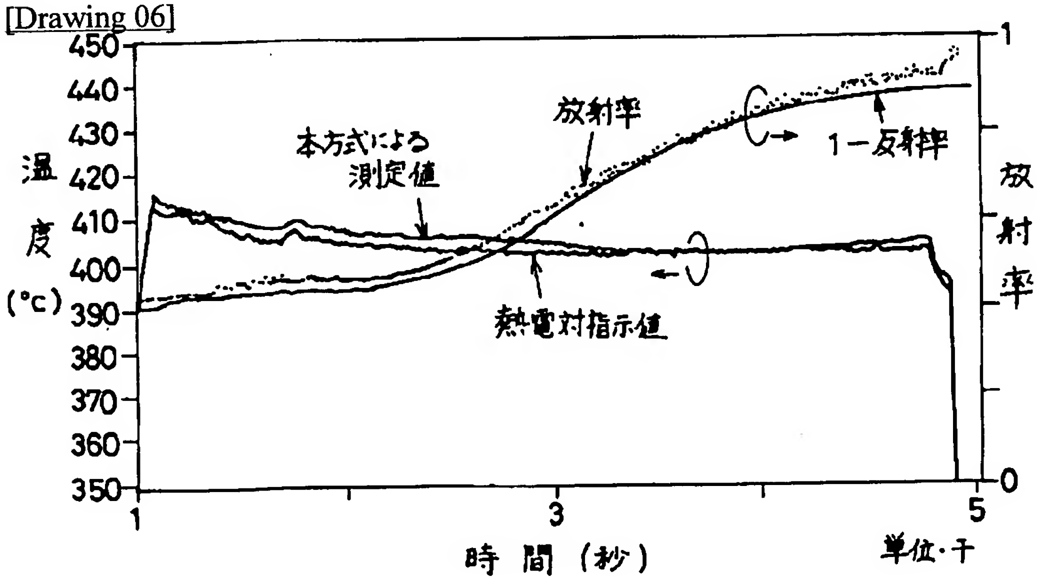

[Drawing 05]



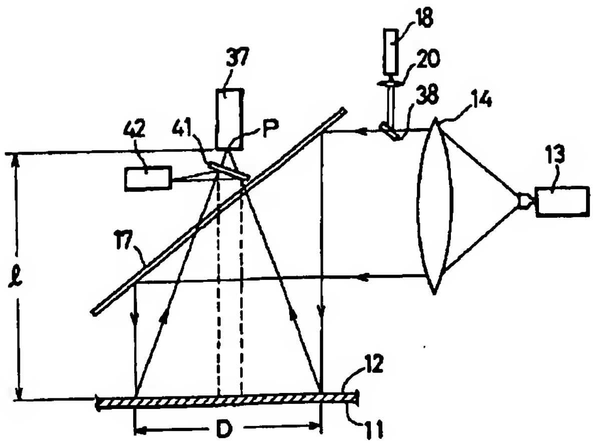

[Drawing 07]




[Drawing 06]




[Drawing 11]




[Translation done.]